Some New and Rare Corals from Funafuti.

By G. C. Bourne, D.Sc., F.L.S.

[Read 4th December, 1902.]

(Plates 5 & 6.)

Professor Judd has kindly sent me for examination two species of Turbinolid corals and one specimen of an Oculinid coral, dredged from a depth of 200 fathoms off Tutanga, during the recent expedition to Funafuti.

The Oculinid coral, of which only a small fragment was obtained, is undoubtedly *Lophohelia tenuis*, Moseley. So far as I am able to determine, only one specimen of this species has previously been recorded, and that was dredged by the 'Challenger' from a depth of 375 fathoms between Panglao and Siquijor Islands in the Philippines. The species is distinguished from *L. arbuscula* by the distinct costæ ornamented with longitudinal rows of minute granules, which run down to the basis of the calicles. As Professor Moseley * lamented the inaccuracy of the figure which accompanied his description of this species, I have given in Pl. 5. fig. 1 an enlarged photograph of the specimen from Funafuti, but the enlargement is not sufficient to show the characteristic granulated costæ. My specimen is smaller than Moseley's, the length of each calycle being 3 mm., and the diameter of the mouths of the largest calycles does not exceed 2 mm.

Of the seven Turbinolid corals sent to me, two are pedunculate and five are free forms. They all have two circlets of pali of unequal sizes, unequal and highly exsert septa, arranged in six systems and four cycles. They belong, therefore, to the subfamily *Trochocyathaceæ*, as defined by M.-Edwards and Haime and subsequently re-modelled by Duncan. I was at first inclined to believe that the pedunculate specimens were the nurse-stocks from which the free forms had been liberated, but closer inspection revealed such differences in the costæ and the granulations on the surfaces of the septa, as to leave no doubt that they belong to distinct species.

The pedunculate specimens must be placed in the genus *Trochocyathus*, as they agree exactly with Milne-Edwards and

* H. N. Moseley, 'Challenger' Reports, Zoology, vol. ii. 1881.

Haime's definition of that genus:—"Le polypier est simple, pédonculé ou subpédicellé, ou ne présente à sa base que des traces d'une adhérence ancienne. La columelle est bien développée et se compose de tigelles prismatiques ou tordues qui se disposent en faisceau ou en série. Les palis sont bien développés, entiers, libres dans une assez grande étendue, inégaux suivant les couronnes auxquels ils appartiennent; ils se trouvent devant toutes les cloisons, excepté devant celles du dernier cycle. Les cloisons sont débordantes, larges et striées latéralement; la muraille est nue ou ne présente qu'une épithèque rudimentaire." As they have simple wedge-like costæ they belong to § A (*Trochocyathes striés*), and as they have six equal systems and four complete cycles of septa they belong to §§ B of the genus.

Trochocyathus vasiformis, n. sp. (Pl. 5. figs. 6 & 7.)

Corallum pedunculate and vasiform, fixed by an expanded encrusting base. Calycular fossa oval, fairly deep. Septa in six systems and four complete cycles; primary and secondary septa subequal in size and conspicuously exsert; tertiary septa smaller and less exsert; quaternary septa small, the lateral faces of the septa covered with rows of granules horizontally arranged. Costæ of the first three cycles simple, ridge-like, extending down to the peduncle, those of the fourth cycle shorter and less prominent. Peduncle minutely granular. Pali in two circlets of unequal size; those of the smaller circlet correspond to the primary and secondary septa; the larger pali in front of the tertiary septa, large, with lateral lobes and coarse granulations; no pali in front of the quaternary septa. Columella consisting of from six to eight contorted trabeculæ.

Habitat. Funafuti.

All the species of *Trochocyathus* described by M.-Edwards and Haime are fossil, but a living species, *T. Victoriæ*, has since been discovered by Tenison Woods * near Port Jackson, Australia, and Duncan † states that another living species has been found in the W. Indies. I am not, however, able to find the authority for the latter statement. The species from Funafuti is distinct, and is an interesting example of a com-

* J. E. Tenison Woods, Proc. Linnean Soc. N. S. Wales, ii. 1878, p. 304.

† P. Martin Duncan, Journ. Linn. Soc., Zool. xviii. 1884, p. 22.

paratively deep-sea form of which the allied species are, with two exceptions, found only in the fossil state.

The larger of my specimens is attached to a dead and corroded specimen of the same species, and looks at first sight as if it had been budded off from it. But it is clear on close examination that this is a case of simple attachment, and the coral is solitary and not compound. This specimen measures 20 mm. in height; the greater diameter of the calyx is 12 mm. and the lesser diameter 10 mm.

The second specimen is smaller, the calyx measuring 7×6 mm., and the fourth cycle of septa is incomplete, consisting of 18 septa only. This is clearly a young individual in which the fourth cycle is not yet fully developed; and it is worth noting that the quaternary septa that are present are regularly arranged in pairs, embracing the tertiary septa, and three such pairs are missing, namely, one in the right sulcular and one in each of the right and left sulcolateral systems. In other words, the order of appearance of the septa of the fourth cycle does not conform to Milne-Edwards and Haime's law, as is so frequently the case in other corals. This specimen is attached to a dead fragment of a *Lophohelia*; and a very small and young *Trochocyathus* is growing on the same fragment, having six larger primary septa, six smaller secondaries, and only an indication of the tertiaries.

The five free Turbinolids are characterized by the presence of five (in one specimen six) long and slender spines projecting outwards and downwards from the lower moiety of the calyx. They show some resemblance to *Deltocyathus italicus*, var. *calcar* of Pourtales, but differ from that species in not possessing the characteristic deltoid pali. They are clearly very closely related to *Turbinolia Mantelli*, figured but not described by G. A. Mantell, in a paper on the Geology of New Zealand, in the Quarterly Journal of the Geological Society of London, vol. vi. 1850, pl. 28. fig. 18. Milne-Edwards and Haime record this species among the doubtful forms of *Trochocyathus* as *Trochocyathus* (?) *Mantelli*, and call attention to its close affinity to *Trochocyathus armatus*, Michelotti, and *T. perarmatus*, Tallavignes. I have not been able to refer to Michelotti's figures of *T. armatus*, but it appears from the description to differ from my specimens in the shape of the calyx and the character of the pali; while Rouault's figure of *T. perarmatus*,

a species differing from *T. armatus* only in possessing six spines instead of five, shows deltoid pali, and the spines are much shorter and thicker than in my specimens. Mantell's figure of *T. Mantelli* shows only the base of the specimen, the mouth of the calyx being imbedded in the rock in which it was found, but, as far as can be seen, the proportions of the spines and the characters of the costæ agree very closely with my specimens. In the absence of a description and of any information about the characters of the septa and pali, it is not possible to say whether the species are identical or not.

Dennant's *Stephanotrochus Tatei*, though superficially extremely like the Funafuti specimens, differs entirely from them in the arrangement of the septa and in the absence of pali (Trans. Royal Soc. S. Australia, xxiii. 1898, p. 117, pl. 3. fig. 1, *a–e*).

I must therefore describe the Funafuti specimens as a new species.

Trochocyathus hastatus, n. sp. (Pl. 5. figs. 2–5.)

Corallum free, short, bowl-shaped, with a scar of attachment at its base. Calycular fossa oval, deep. Septa in six systems and four cycles, the fourth sometimes incomplete. The primary septa somewhat larger than the secondaries, both very exsert; the tertiary and quaternary septa smaller and less exsert; the faces of the septa covered with prominent pointed granulations arranged in radiating rows. Costæ broad, closely crowded together, of nearly equal width, extending down the upper two-thirds of the calyx, covered with fine granulations. The costæ of each primary septum with the two quaternaries adjacent to it produced outwards to form six long horizontally projecting tapering spines; in cases in which five spines only are present, the deficiency occurs at one end of the long axis of the calyx. The base of the corallum smooth, and often nacreous in appearance. Pali in front of the primary and secondary septa small and inconspicuous; those in front of the tertiary septa large, prominent, and covered with spiniform granulations. Columella relatively small, consisting of from 10–12 contorted trabeculæ.

Habitat. Funafuti.

Of the five specimens of this species, one, a dead and worn example, has six spines corresponding to the six primary septa, the others have five spines. The number of spines being

variable in this case, it seems probable that *T. armatus*, Mich. and *T. perarmatus*, Tallavignes, are only varieties of one species. *T. Mantelli* has six spines. It is remarkable that two quaternary costæ cooperate with each primary costa in the formation of a spine, and in one case as many as five costæ unite to form a spine, viz., one primary, one tertiary, and three quaternary. In three specimens the fourth cycle of septa is complete, in the other two specimens two quaternary septa are missing in one of the systems adjacent to the long axis of the calyx, and in each case the tertiary septum, which they would, if present, have embraced, is devoid of a palus. But the missing quaternaries are not adjacent to the primary septum, which is devoid of a spine, as described by M.-Edwards and Haime for *T. armatus*.

The following are the measurements of the five specimens :—

	mm.	mm.	mm.
A.	Depth of calyx, 12	Longer diameter, 18	Shorter diameter, 16
B.	„ „ 12·5	„ „ 15·5	„ „ 13·5
C.	„ „ 11	„ „ 15·5	„ „ 13·5
D.	„ „ 9	„ „ 13	„ „ 12
E.	„ „ 11·5	„ „ 16·5	„ „ 15

Note.—Since this paper was written Dr. A. Alcock has published an account of three species of corals, very similar to the form described above as *Trochocyathus hastatus* (Report on the Deep-Sea Madreporaria of the 'Siboga' Expedition, Leiden, 1902). Two of these he has described under the names of *Odontocyathus sexradiis* and *Odontocyathus stella*; the third specimen he has not named because it was in too imperfect a condition for accurate diagnosis.

When my paper was read before the Linnean Society it was naturally suggested that, as the Funafuti specimens are so very similar to those described by Dr. Alcock, they might belong to one of his species, and certainly to the genus *Odontocyathus*, Moseley.

The Funafuti specimens which I have named *Trochocyathus hastatus* differ from *Odontocyathus sexradiis* in the following particulars: the primary septa are not so conspicuously exsert; the edges of the bowl-shaped corallum are not scalloped; there are only four cycles of septa, instead of five and parts of a sixth as in *O. sexradiis*; the pali in front of the tertiary septa are by

far the largest (in *O. sexradiis* "the pali of the innermost crown are the smallest").

Trochocyathus hastatus differs from *Odontocyathus stella* in being bowl-shaped, whereas the latter species is flat, in the 2nd cycle of septa being large and nearly as exsert as the 1st cycle, whereas in *O. stella* the 2nd cycle is least exsert of all but the quaternaries, and in the character of the pali. So far as can be ascertained from the meagre description, *T. hastatus* is also quite distinct from the unnamed specimen.

There is, therefore, no question of identity of species, and I have only to consider whether the Funafuti specimens should be classed, along with the Siboga specimens, in the genus *Odontocyathus*. Having fully considered this question before Dr. Alcock's paper came into my hands, I see no additional reasons for altering my original opinion that the Funafuti specimens should be placed in the genus *Trochocyathus*, M.-Edw. & H., and not in the genus *Odontocyathus*, Moseley.

I have no doubt that the Siboga specimens should be placed in the same genus as those from Funafuti. Their affinities are obvious. But I consider that Dr. Alcock is in error in placing them in the genus *Odontocyathus*. This genus was established by Moseley to receive a deep-sea turbinolid having *twelve* stout spines irregularly beset with small pointed tubercles, the spines corresponding to the primary and secondary costæ. In the Siboga and Funafuti corals there are *six* or *five* smooth spines corresponding to the six primary costæ. In Moseley's *Odontocyathus* the twelve radiating basal ridges corresponding to the twelve spines reach to the central basal scar and are covered with tubercles, a feature which is absent in the Siboga and Funafuti specimens. In fine, a glance at Moseley's figures is sufficient to satisfy one that neither Dr. Alcock's specimens nor mine have any close resemblance to *Odontocyathus*—though all these forms come under the definition of the *Trochocyathes armés* of Milne-Edwards and Haime.

It was not, and it is not now, my intention to criticise Moseley's genus. He said that his coral was of such a peculiar shape that a new genus must be created for its reception. If we accept his genus, we must regard the twelve spines and the basal tubercles as diagnostic characters, for there are no others to distinguish it from the genus *Trochocyathus*. These diagnostic characters are not shared by the Funafuti and Siboga specimens.

Should we, then, place them in the genus *Trochocyathus*, or create a new genus for their reception? After considering this point carefully, I decided that there was no occasion for creating a new genus, for there are no characters, either of septa, costæ, costal spines, basal scar, pali, or columella, which do not come under the definition of the genus *Trochocyathus* as given by Milne-Edwards and Haime, a definition which has never been altered by any subsequent authority. In these days, when a series of imperceptible gradations is held to be a good reason for uniting species formerly considered distinct, it is no time to establish new genera among forms connected by equally imperceptible gradations.

28*th January*, 1903. G. C. B.

[Addendum.—It was only after this paper had been sent to the press that I received three discoid corals which, on account of their small size, had been overlooked, and were found again when the collections from Funafuti were being finally sorted for distribution to various museums.

The specimens in question are minute discoid forms, the largest measuring 4 mm., the smallest 3 mm. in diameter. In the smallest specimen there are six costæ, corresponding to six primary septa, which are more prominent than the rest; in the two larger specimens there are six distinct but short and stout costal spines, corresponding to the six primary septa. Coming as they do from the same locality, these small discoid corals may safely be identified as the young forms of *Trochocyathus hastatus*. They are of considerable interest, for they show that the free forms of this species are derived by strobilization from a nurse-stock or trophozooid, and that the arrangements of septa, pali, and spines characteristic of the adult are the result of secondary growth after the young forms have separated from the nurse-stock.

The three specimens are shaped like flat discs, the smallest being rather less than 1 mm., the largest about $1\frac{1}{2}$ mm. in thickness. The upper and lower surfaces of each present a large scar of attachment, extending over nearly the whole diameter of the disc. On one surface, which may be called the lower surface, the interseptal loculi are more or less filled up with a compact calcareous deposit, so that the outlines of the septa are obscured or hardly distinguishable. On the other surface

there is a distinct calycular fossa, but, excepting in the largest specimen, the septa scarcely project above the surface of the disc, and their upper edges give evidence of their having been recently severed across.

The flat discoid shape of these young corals and the presence of a large scar of detachment on their upper as well as on their lower faces show that they are not pedicellate forms that have simply been detached at the base, as is the case in several species of *Flabellum*, but that they must have formed by the transverse division of a fixed nurse-stock, just as the ephyræ of *Aurelia* are formed from a strobila. Such a process of strobilization is extremely rare in corals, but it has been described by Semper * in *Flabellum variabile*. It is not exactly the same thing as the formation of anthocyathi from the trophozooid of *Fungia*; for in the latter case the margins of the calycle of the trophozooid expand laterally to form a broad disc-shaped *Anthocyathus* before detachment takes place. The theca of the *Anthocyathus* is on the lower surface, and the scar of detachment is small relatively to the diameter of the *Anthocyathus* itself. After the first *Anthocyathus* is detached a new one is formed by the upgrowth and subsequent outgrowth of the septa within the scar at the upper end of the trophozooid, and this is in turn detached, the process being repeated three or four times, but not more so far as is known. In *Trochocyathus hastatus* the thecal walls of each disc-shaped young specimen are nearly vertical, and the scar of detachment is nearly as large as the disc itself. Moreover, it is clear that the young forms are not successively completed and then detached, as in *Fungia*, but that a number of young forms are segmented off from the trophozooid, either simultaneously or in rapid succession, before the septa have time to grow or to repair their divided edges.

The smallest of the three specimens from Funafuti appears to be the most recently detached of the three. It measures rather less than 3 mm. in diameter and 1 mm. in thickness. The upper and lower surfaces are flat, and the margin of the disc constituting the theca is evenly rounded and marked with thirty-six costæ, having the form of low ridges (Pl. 6. fig. 8). Six of these costæ are somewhat more prominent than the rest,

* Zeitschrift für wissenschaftliche Zoologie, Bd. xxii. p. 235.

but are not yet developed into spines. In the large scar on the lower surface of the disc, thirty-six septa, corresponding to the thirty-six costæ, and a central columella can be more or less distinctly seen, but the interseptal loculi and the central cavity are already largely filled up by a compact calcareous deposit, so that the outlines of the septa are blurred and difficult to make out. On the upper surface, on the other hand, there is a distinct calycle in which the septa are conspicuous and the interseptal loculi are relatively deep. The centre of the calycle is occupied by a fascicular columella consisting of numerous irregularly shaped calcareous nodules, the more peripheral of which are sometimes united with the inner ends of the larger septa, but there are no pali.

The thirty-six septa are arranged in six systems and four orders, those of the first three orders forming complete cycles. The septa of the first order correspond to the six more prominent costæ, are larger and extend further towards the centre of the calycle than those of the other orders.

The second and third orders are complete, comprising six and twelve septa respectively. The fourth order is incomplete, comprising only twelve septa, and in each system the septa of the fourth order are situated in the loculi between the septa of the first and third; there are no quaternary septa in the loculi between the secondaries and tertiaries. There is little difference in size between the secondary, tertiary, and quaternary septa. If anything, the tertiary septa are rather longer than the secondary, and in some of the systems the quaternaries are as large as or larger than the tertiaries.

Though the costæ are fairly prominent, the upper edges of the septa stand but very little, if at all, above the level of the disc.

An outline of one of the primary septa is given in fig. 8 *a*. It can be seen that the upper edge is horizontally truncated, giving evidence of its recent severance from the corresponding septum of the individual next above it during strobilization. But although the severance is obviously recent, sufficient time must have elapsed for processes of repair and regrowth to have set in, for on the upper margin there are calcareous granules which, as is evident on microscopical examination, have been recently deposited on the truncated edge. Similar granules are discoverable on the upper edges of all the septa, showing that the process of regrowth has already begun.

The second specimen measures rather less than 3·75 mm. in diameter, and is evidently somewhat older than the first. The costæ corresponding to the six primary septa are produced into as many stout conical spines (Pl. 6. figs. 9 & 10), but the remaining costæ are not so prominent as in the first specimen, as the theca has been thickened by a secondary deposit, probably of an epithecal character. The lower surface of the disc is perfectly flat and presents a large scar, in which the septa and columella are distinguishable, though the spaces between them are filled up with secondary calcareous deposit.

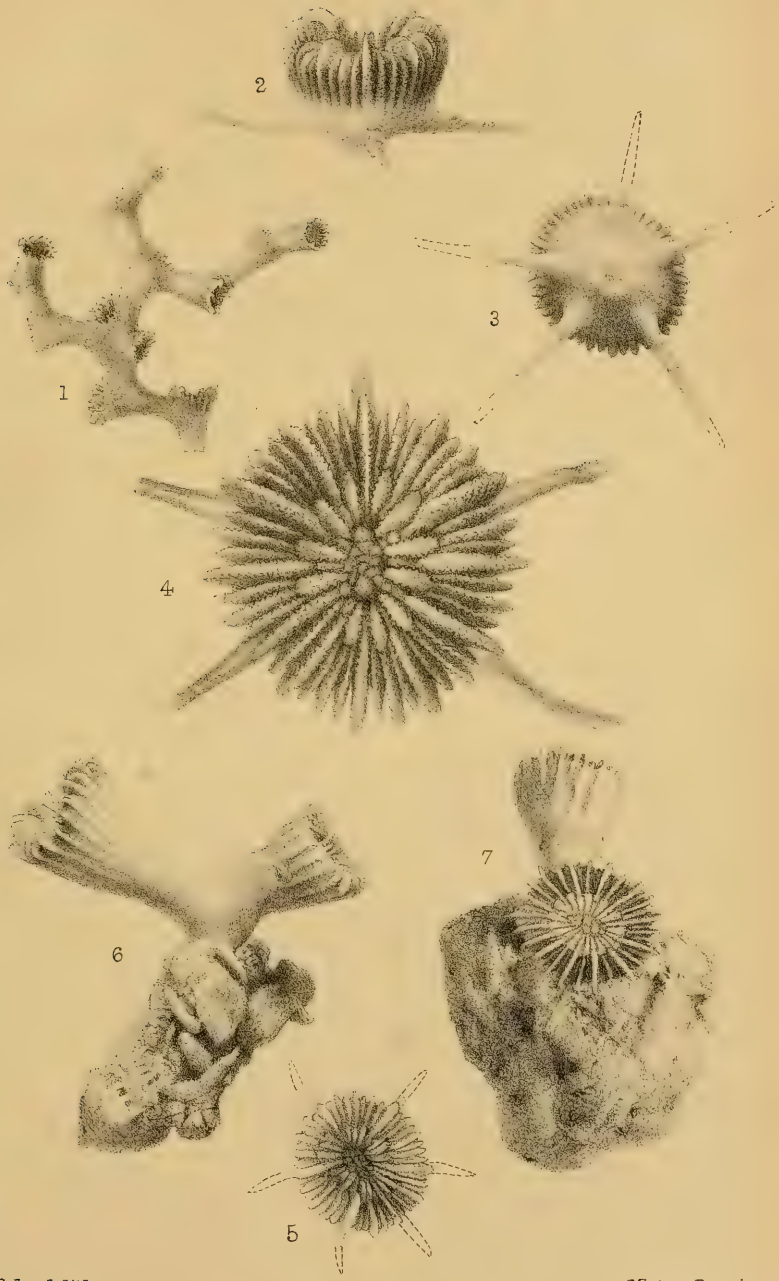
On the upper surface the calycle is somewhat deeper than in the first specimen, and the septa are slightly more exsert. The columella also is more abundant, but there are no distinct pali. As in the first specimen there are six systems, and three complete orders and a fourth incomplete order of septa. In this specimen the septa do not reach so far towards the centre of the calycle as in the first, but the primaries are distinctly the longest. Although the septa project but very little above the level of the disc, their upper edges have evidently advanced further in regrowth than was the case in the first specimen: they are no longer horizontally truncated, but are rounded and produced into tiny projecting spinose granules. The process of regrowth has been most rapid in the tertiary, least rapid in the secondary septa, so that the last named are now the smallest of all the cycles. Further, it may be observed that while the costæ of the secondary and quaternary septa are very inconspicuous, those of the tertiary septa have increased in size, and form two prominent swellings or ridges between every two adjacent spines. In other words, the tertiary septa have grown faster than the others, and it should be borne in mind that it is in connection with the tertiary septa that the conspicuous crown of pali, characteristic of the adult specimens of *T. hastatus*, is developed.

The third specimen measures 4 mm. in diameter, and is considerably further advanced in growth than the other two. The six spines, corresponding to the primary septa, are not much larger than in the second specimen, but the disc is thicker and the scar on the lower surface is so completely filled up with the secondary deposit that only a circular depression is left, corresponding very nearly in size and appearance with the scars

visible on the under surfaces of the adult specimens of *T. hastatus*.

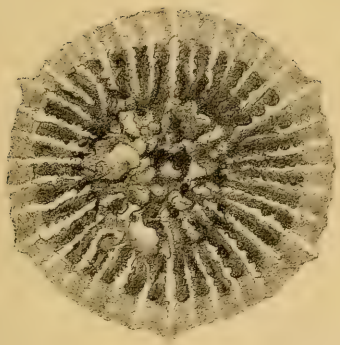
Associated with the filling up of the scar is a considerable extension of the epithecal deposit on the lower surface, obliterating the costæ, and giving the same nacreous lustre to this region as is seen in the adult specimens. This specimen was apparently dead when collected and had suffered some erosion and injury, for the interseptal loculi are partly filled up with Foraminifera, and the upper parts of several of the septa are broken off. I am able, however, to count thirty-six septa, whose arrangement is identical with that of the first and second specimens, but they have progressed much further in growth.

The uninjured septa, as is shown in Plate 6. fig. 11, project well above the margin of the calycle and are of unequal sizes. Those of the first order are the most exsert, then follow those of the third, then those of the second order, and the quaternaries are the least exsert of all. The inner ends of the septa are so much damaged that it is difficult to say anything certain about the presence of pali, but there are indications of a prominent inner spine separated by a notch from the main part of the septa of the first and third cycles, so I am inclined to think that the pali are being developed at this stage. The specimen, however, is of great interest, for it clearly indicates that the greater part of the corallum of the adult *Trochocyathus hastatus*, with its characteristic arrangement of septa and pali, is formed by the upgrowth of the septa from the scar of detachment on the upper surface. In the order of their appearance the septa follow the law of Milne-Edwards and Haime; that is to say, that in each of the three first orders the septa appear simultaneously and form three complete cycles. The septa of the fourth order are twelve in number and appear in the interseptal loculi 1+3, 3+1, in each system forming an incomplete cycle. The septa of the fifth order appear very late in the interseptal loculi 3+2, 2+3, in each system, and with the septa of the fourth order form a complete fourth cycle. But during the growth from the young to the adult form, the rate of growth of the septa does not follow this law. The six primary septa are always predominant in size, but the secondaries, which in adult specimens are equal or nearly equal to them, lag behind in the earlier stages of regrowth, and are surpassed by the tertiaries,



CORALS FROM FUNAFUTI.

9



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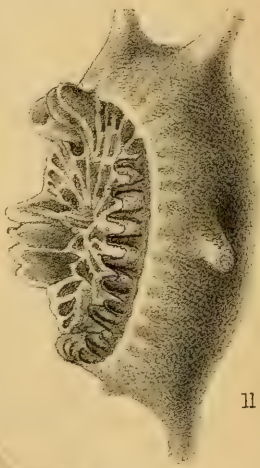
8a.

9a.



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F.H.Michael lith. Mintern Bros. imp.

CORALS FROM FUNAFUTI.

this variation in rate of growth being doubtless associated with the great size of the pali belonging to the last-named cycle. It is a peculiarity that where there is an irregularity of growth leading to the suppression of one of the six spines, it is always associated with the suppression of one of the tertiary septa and its palus together with the septum of the fifth order adjacent to it.

10*th March*, 1903. G. C. BOURNE.]

DESCRIPTION OF THE PLATES.

PLATE 5.

Fig. 1. *Lophohelia tenuis*, Moseley, enlarged.
2. Side view of *Trochocyathus hastatus*.
3. Basal view of the same species.
4. Enlarged view of the calyx of the same species.
5. Calyx of a 6-spined individual of the same species.
6. Lateral view of *Trochocyathus vasiformis*, n. sp.
7. Calyx of the same species, showing septa and pali.

PLATE 6.

Fig. 8. Enlarged view of the upper surface of the youngest specimen of *Trochocyathus hastatus*, showing thirty-six septa divided into six systems and four orders. The six primary septa are larger than the rest but have not yet developed spines.

8*a*. Lateral view of one of the primary septa of the same specimen showing the horizontally truncated upper edge.

9. Enlarged view of the upper surface of an older specimen of the same species; the same number of septa is present as in the younger specimen, but conspicuous costal spines are developed in connection with the six primary septa.

9*a*. The same specimen, natural size.

10. Ventral view of the same specimen, showing the interseptal loculi largely filled up by secondary calcareous deposit.

11. Enlarged lateral view of a still older specimen, which has been somewhat damaged, showing the upgrowth of the septa to form the calycle of the adult.